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SPEED DEFICIENCY IN SHIPBUILDING CONTRACTS FROM THE POINT OF VIEW OF THE MAIN ENGINE MANAGEMENT

I. Basterretxea[1,2], **J. Vila**[1,3], **I. Loroño**[1,4], **L. Martín**[1,5] and **M. Herrera**[1,6]

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ABSTRACT

This article is related to the shipbuilding contracts and its purpose is to provide a method of calculation of the economical damages sustained by a purchaser due to the speed deficiency of the vessel delivered by the shipyard. The method is easy to be put into practice in all types of ships because it is based on the management of the main engine and does not use economical terms which may make it confusing and volatile.

Keywords: Shipbuilding contract, propulsive power, speed contracted or agreed, speed deficiency, ship extra costs

INTRODUCTION

The speed deficiency in sale contracts of ships, either existing or new building, involves claims whose quantum is difficult to calculate due to the fluctuations of economical parameters. In case of new ships delivered by the shipyard, the damages are usually higher due to a longer lifetime.

This article aims to present an assessment method for the economical quantum of speed deficiency claim from the point of view of the main engine management. The calculation is mainly based on the excess of fuel consumption arisen from the power increase of the main engine necessary to reach the speed agreed in the ship-

[1]Professor University of the Basque Country, Maria Diaz de Haro, 68 48920 Portugalete, Spain. [2]Email: imanol.basterrechea@ehu.es, Tel. 946014792, Fax. 946017700. [3]Email: jesusangel.vila@ehu.es, Tel. 946014859, Fax. 946017700. [4]Email: inaki.lorono@ehu.es, Tel. 946017780, Fax. 946017700. [5]Email: leopoldo.martin@ehu.es, Tel. 946014119, Fax. 946017700. [6]Professor, Email: mariamercedes.herrera@ehu.es, Tel. 946014869, Fax. 946017700.

building contract. Moreover other consequences caused by a major power should be taken into account as main engine wear and tear, lube oil consumption, reduction of payload, etcetera. One of the advantages of the method is that it can involve all types of ships without using economical variables related to fluctuations of freight market, delays for arriving out of time to the ports of loading or unloading in regular lines, etcetera. Nevertheless the uncontrollable price of oil products may make the results of this method volatile.

METHODOLOGY

One of the first problems for the shipyard is that the propulsive power to reach a specific speed must be known before the sea trials are carried out. Therefore the resistances of the hull and its appendices at a specific speed must be determined in advance by statistical methods and model tests. The speed deficiency in shipbuilding contract is usually caused by an error in the calculation of the resistances for a particular speed.

On the other hand, the shipbuilding contract clauses related to the speed, power and consumption will also be considered as well as the clause called *liquidated damages* which provides the way of settling damages for speed deficiency.

In case the speed of the new vessel does not reach the speed agreed in the contract, this research will provide us with a simple method to assess the increase in fuel consumption, oil lubrication and maintenance of the main engine to reach that agreed speed, without prejudice to the main engine life.

Calculation of required propulsive power at the initial design stage of the ship

Before the construction of the ship, the ship's main particulars required by the buyer are provided to the shipyard where the basic ship design is carried out involving the calculation of the main engine power by using some of these main particulars. At this regard, both project speed and any other speed may be determined, respectively,

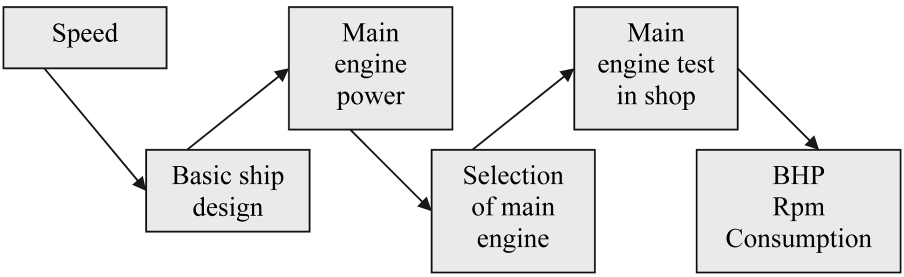

Figure 1.

by means of proximate methods as J. Mau or D.G.M. Watson and J. Holtrop & G.G.J. Mennen or L.K. Kupras. Thus the relation between the propulsive power and the ship speed may be known before the beginning of the shipbuilding and the steps taken by the shipyard are shown in figure nº1.

Once the propulsive power is assessed, a main engine is chosen by the shipyard to provide the ship with enough power to reach the agreed speed (service or maximum speed depending on the contents of shipbuilding contract). A little difference between the shop or sea trial (around 3%) is taken into account by the shipyard since the main engine works in a different way either on board the ship or in the shop.

Shipbuilding contract

The ship speed is agreed under the shipbuilding contract at a specific draught (mainly the draught in sea trials), power (BHP) and sea conditions. Sometimes a sea margin (around 15% or less) may be agreed in the contract to take into account the loss of speed caused by the sea condition (swell, waves, wind, etcetera…).

Fuel oil consumption for a given propulsive power is also agreed under the contract according to the details of the shop trials. This data can be known in advance by the shipyard by means of the results of main engine shop trial (considering the additional percentage of around 3% cited previously).

A special compensation clause for damages due to speed deficiency is usually included in the standard forms of shipbuilding contracts (SAJ, AWES, MARAD, Norwegian Shipbuilding Contract or NEWBUILCON). For instance, the BIMCO's new standard agreement says as follows:

8. Speed Deficiency

If the speed of the Vessel as stated in Box 4D(ii) is not achieved in the manner stated in the Specification or Clause 2(b)(i) the following shall apply:

(a) There shall be no adjustment of the Contract Price except to the extent provided in Sub-clause 8(b).

(b) lf the reduction in speed is greater than 2/10ths of a knot, the Contract Price shall be reduced by the amount stated in Box 13(i) for each whole 1/10th of a knot reduction in speed in excess of 2/10th of a knot as liquidated damages up to the maximum amount stated in Box 13(ii).

(c) lf the reduction in speed would entitle the Buyer to a reduction in the Contract Price greater than the maximum amount stated in Box 13(ii), the Buyer shall have the option to terminate this Contract in accordance with Clause 39(a)(iv) (Suspension and Termination).

According to this clause, the contract price is not to be reduced if the loss of speed is equal or minor to 0.20 knots in respect to the speed agreed in the contract. However the contract price will be reduced by an agreed amount for each whole 0.10

knots reduction in excess of 0.20 knots up to a maximum sum stated in the contract.

Of course, the speed deficiency may be negotiated in the contract by means of different clauses depending on the form of the agreement. There are even many shipbuilding contracts where any compensation is not agreed with regard to the speed deficiency and the disputes are finally brought before the Court.

Calculation of extra fuel consumption to reach the agreed speed

The minimum service speed agreed under shipbuilding contract is subject to a given propulsive power (BHP), vessel's draught, sea margin or whatever other condition. Under the standard form contract NEWBUILDCON, for instance, it is agreed a minimum service speed under following conditions:

— Minimum service speed at design draft
— Minimum service speed at a percentage of the main engine's maximum continuous power
— Minimum service speed at a specific consumption rate
— Sea margin

In this way, if that minimum service speed is not reached at above conditions during the ship trials, the power of the main engine may be risen up to reach it. Unfortunately this major power would mean a higher consumption of fuel oil along the ship's life which will serve us for the calculation of the compensation.

Calculation of main engine life reduction

The life of the main engine may be represented in the figure nº 2 by the bathtub curve (figure nº2) where the conditional probability of failure is related to the main engine's lifetime. During the first months of ship operation (infant mortality) the incidence of failure is high but it is followed by a constant or gradually increasing probability of failure (constant zone). Then, after several years of operation at the same minimum level, the probability of failure begins to rise in the wear-out zone due to wear and tear of the engine.

Although the shape of that curve depends on the type of engine, it may be considered in the research an average lifetime of twenty years before the wear-out zone.

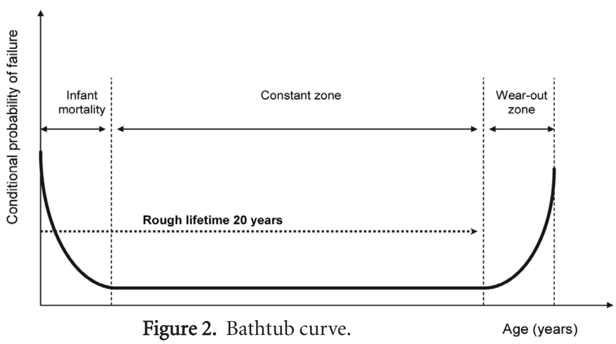

Figure 2. Bathtub curve.

The increase of power output of the main engine to reach the agreed speed entails a reduction of main engine lifetime. In order to stop this reduction, the main engine maintenance should be carried out more frequently and therefore the related costs would be higher as it will be studied in the next chapter.

Calculation of the extra cost of main engine maintenance

Higher power output involves a major wear and tear in the parts of the main engine and consequently its lifetime is reduced. To keep the same lifetime, the ship manager is obligated to carry out maintenance works during shorter periods of time which will depend directly on the difference between the power stated in the contract for the agreed speed and that power which is really needed for the ship to provide the agreed speed. A way of this extra cost calculation might be based on a percentage of main engine maintenance annual cost.

Calculation of the extra cost of lube oil consumption

The lube oil consumption would be higher in case of the main engine rate (revolutions per minute) being increased to reach agreed speed. This excess of lube oil consumption may be assessed from the real data of the main engine in service. This means to compare the lube oil consumption at the propulsive power corresponding to the agreed speed and at the power output needed for the ship to provide the agreed speed. If there would not be previous experience to obtain those data, the lube oil consumption may be considered proportional to the revolutions per minute of the main engine.

Freight loss

If the ship has to consume more fuel to reach the agreed speed, the fuel loaded in her tanks to keep the same sea passage range would be greater and consequently the payload would be reduced. This loss of cargo would mean a lower freight for the same sea passage.

PRACTICAL CASE

This method of calculation for damages caused by speed deficiency under shipbuilding contract is put into practice on an existing oil tanker of 150,000 dwt. The research will be carried out for a speed deficiency of 0.1 knots between the contractual and real service speed once the allowance is taken.

Specifications of the contract

The shipbuilding contract is agreed according to the following guarantees:

- 150,000 tons deadweight SUEZMAX oil tanker
- Specified speed without sea margin at the condition of clean bottom in sea trial condition within Beaufort 2:

- 16.2 knots at the mean summer draught of 16 meters and at 90% MCR (14.560 kW) of main engine.
- 16.8 knots at the mean ballast draught of 7 meters and at 90% MCR (14.560 kW) of main engine.

— Settlement of damages: If the deficiency in actual speed of the vessel amounts to or exceeds two-tenths of one knot below the specified speed of the vessel at the design draught, the Builder shall pay compensation to the Buyer for the excess speed deficiency.
— Maximum Continuous Rating (MCR): approx.16.178 KW
— Normal Continuous Rating (NCR = 90% MCR): Approx. 14.560 kW
— Consumption of fuel oil guaranteed (at NCR): 173,07 g/kW/h.

Data collecting from sea and shop trials

The result of sea trials with the ship loaded at summer draught of 16 meters is shown in table 1.

Vessel at maximum loaded condition	75% MCR	NCR (90% MCR)	MCR
Corrected speed (knots)	14.97	15.9	16.31
BHP (kW)	12,133	14,560	16,178
Consumption (g/kW/h)	173.76	173.07	175.66

Table. 1.

In addition, the outcome of these trials at ballast draught of 7 meters is shown in table 2.

Vessel at ballast condition	75% MCR	NCR (90% MCR)	MCR
Corrected speed (knots)	15.6	16.6	17.5
BHP (kW)	12,133	14,560	16,178
Consumption (g/kW/h)	173.76	173.07	175.66

Table. 2.

Data collecting from the ship in service

The following data are collecting from the ship's experience along her life:
— Navigation time: 264 days per year
— Navigation time at summer draft: 158 days per year
— Navigation time at ballast condition: 106 days per year

— Lubricating oil consumption of main engine at BHP 14,560 kW (NCR): 715 liters per day
— Lubricating oil consumption of main engine at BHP 14,925 kW: 725 liters per day
— Cost of main engine's maintenance:
  • Spares: 45,000 annual USD
  • Cost of repairing and maintenance works: 25,000 annual USD
— Average freight: 24,000 USD per day

Extra cost of fuel consumption

The speed of 16.9 knots with the ship sailing at maximum condition load and at 90% MCR is 0.1 knot below the agreed speed, once deducted two tenths of a knot allowance. On the other hand, the speed at ballast condition is considered within the agreed parameters.

The full relationship between power, speed and consumption is shown in table and figure nº 3 and obtained from the real data of the sea trials (shown in table nº 1 and in bold in table nº 3) by using *spline* interpolation. It is also marked within a double cell the minimum agreed speed along with the power and related consumption.

BHP (kW)	**11.881**	12.023	13.585	13.889	14.214	**14.560**	14.925	15.311	15.718	16.145	**16.178**	16.592
SPEED (KNOTS)	**14,8**	14,9	15,6	15,7	15,8	**15,9**	16,0	16,1	16,2	16,3	**16,312**	16,4
CONSUMPTION (kg/h)	**2.068,0**	2.090,4	2.352,2	2.404,5	2.460,3	**2.519,9**	2.583,0	2.650,6	2.730,2	2.833,0	**2.841,8**	2.959,4
CONSUMPTION (g/kW/h)	**174,06**	173,87	173,15	173,12	173,09	**173,07**	173,07	173,12	173,70	175,47	**175,66**	178,36

Table 3.

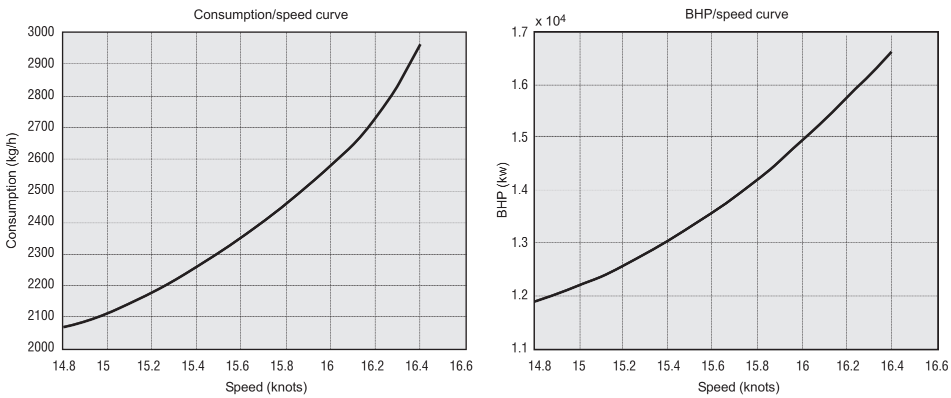

Figure 3.

As it is shown in table nº 3, consumption between real speed of 15.9 knot and agreed speed of 16.0 knot (deducted allowance of 0.2 knots) is increased in 63.1 kg/h (from 2,519.9 kg/h to 2,583.0 kg/h). Bearing in mind a yearly navigation time in loading condition of 158 days, consumption would be increased in 239,275 kg per year. If an average fuel price of USD 0.40 per kilogram is considered along 20 years, the extra annual cost of fuel would be 95,710 x 20 = 1,914,202 USD. However, this figure should be taken into account as an approximation since the fuel price is difficult to determine in future due to the volatile oil products prices as it is shown in figure nº 3.

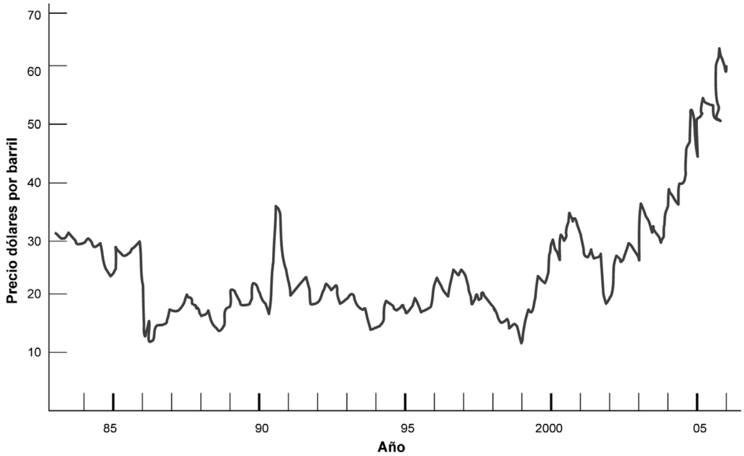

Figure 3. Price evolution of crude oil barrel along last twenty five years.

Extra cost of lubricating oil consumption

When the power of main engine is raised to reach the agreed speed, the lube oil consumption is increased in the same proportion of the engine revolutions. According to the data obtained from the ship full loaded sailing at 16.0 knots, the lube oil consumption is 10 daily litres higher than at 15.9 knots. Therefore the annual increase of lube oil price is estimated in 1.4% [100 x (10 ÷ 715) = 1.4%] and equal to 1,580 litres in 158 days per year at maximum cargo condition.

The lube oil products´ price is mainly dependent on their own additives and is not coming from the crude oil, therefore it is not so volatile as fuel oil and an annual price increase of 3% may be considered based on the inflation rate. For a current price of 1.35 USD per litre, the lube oil extra cost may be assessed as follows:

$$1{,}580 \times 1{,}35 \times \sum_{0}^{n-1} (1.03)^i$$

; where n is the main engine life in years.

In case of 20 years life, the extra cost would be 57,314 USD.

Extra cost of main engine maintenance

According to the experience of the ship managers, the vessel has to carry out an average of three maintenance works per year which means 60 maintenance works in twenty years. Taking into account that the BHP is increased from 14,560 kW (speed 15.9 knots) to 14,925 kW (speed 16.0 knots) in order to reach the agreed speed and, although it is difficult to know exactly how the components of the main engine are worn out, it might be estimated a 5% reduction in the time elapsed between two consecutive maintenance works. In this way, ship managers would need 84 days in order to operate the vessel at agreed speed. In economical words, the engine maintenance cost would also rise by 5% per year and therefore the extra cost would be 70,000 x 20 years x 5% = 70,000 USD.

Freight loss

Assuming the passage at maximum load condition is an average of 15 days long, the payload of the vessel (estimated in 143,000 tons) would be reduced in 22.7 tons [63.1 kg/h x 24 x 15] which means a percentage of 0,016% (100 x 22.7 ÷ 143,000). Taking into account the freight pays for a day according to the worldscale index, an average daily freight of 24,000 USD per day would be reduced in 3,84 USD per day, that would be around a loss of 15,000 USD in 20 years. Nevertheless the loss in payload might be absorbed by the crude oil API or even by the constant itself.

CONCLUSIONS

This calculation method may be useful to determine the quantum of liquidated damages for speed deficiency clause in shipbuilding contracts.

- The variables in the calculation are reduced basically at the fuel oil price only.
- The disadvantage of the calculation is the uncontrollable variation in the evolution of the fuel oil price for the next twenty years which involves a larger difference in the quantum of the claim for speed deficiency.
- The data used in the calculation is obtained from the main engine shop tests and its previous knowledge makes the calculation easier consequently.
- The extra cost in main engine maintenance might be studied more deeply through a regression analysis of statistical results of different engines working between the normal (NCR) and maximum continuous rating (MCR).

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FALTA DE VELOCIDAD EN LOS CONTRATOS DE CONSTRUCCIÓN DE BUQUES DESDE EL PUNTO DE VISTA DE LA GESTIÓN DEL MOTOR PRINCIPAL

INTRODUCCIÓN

La falta de velocidad en los contratos de compraventa de buques, tanto existentes como de nueva construcción, conlleva reclamaciones cuyo importe es difícil de calcular debido a las fluctuaciones de parámetros económicos. En caso de nueva construcción, los perjuicios causados suelen ser mayores debido a que su vida es más amplia.

La intención de este artículo es presentar un método de evaluación del importe económico que supone la falta de velocidad desde el punto de vista de la gestión del motor principal. El cálculo está basado principalmente en el exceso de consumo de combustible que generaría el aumento de potencia necesario para alcanzar la velocidad pactada en el contrato de construcción del buque. Además se tienen en cuenta otras consecuencias de este aumento de potencia como pueden ser el mayor desgaste del motor, el mayor consumo de aceite, la pérdida de porte, etc. Una de las ventajas del método es que puede ser aplicable a todo tipo de buques sin usar variables económicas relacionadas con fluctuaciones del mercado de fletes, retrasos en puerto por no llegar a tiempo en líneas regulares, etc. Sin embargo, la falta de control sobre el precio de los combustibles derivados del petróleo puede provocar resultados volátiles en la aplicación de este método.

METODOLOGÍA

Cálculo de potencia en el diseño básico del buque

Antes de la construcción del buque, el armador informa de las características principales que desea para su buque, siendo el astillero quien desarrolla un proyecto inicial a fin de conocer, entre otros parámetros, la potencia del motor. En este sentido, para calcular la potencia propulsora se pueden utilizar los métodos aproximados de J. Mau y D.G.M. Watson para una velocidad de proyecto, o bien los métodos de J. Holtrop & G.G.J. Mennen y L.K. Kupras para cualquier velocidad (fig. nº 1).

Posteriormente se encarga el motor que proporcione esa potencia con un consumo de combustible en servicio que variará en un pequeño porcentaje con respecto a las pruebas en banco (aproximadamente 3%).

Contrato de construcción

La velocidad se pacta en el contrato de construcción en base a un calado determinado (el que se utilice en las pruebas de mar), un régimen de potencia y unas condiciones atmosféricas determinadas. También se puede pactar unos márgenes en porcentaje de aminoración de la velocidad debido al oleaje, viento y tiempo transcurrido (denominado *sea margin*).

También se pacta el consumo de combustible a determinado régimen de potencia que el astillero puede conocer de antemano de acuerdo con las pruebas de motor en banco, incluyéndose el porcentaje adicional que se comenta en el apartado anterior.

Los contratos de construcción estándar (SAJ, AWES, MARAD, Norwegian Shipbuilding Contract ó NEWBUILCON) tienen una cláusula especial de indemnización por daños y perjuicios debido a la falta de velocidad.

Normalmente el importe de indemnización se calcula por cada décima de nudo de deficiencia hasta un máximo por encima del cual el contrato se podría rescindir. Asimismo se concede una falta de velocidad de gracia de 0,2 nudos normalmente por debajo de la cual no existe indemnización.

Por supuesto, existen otras muchas modalidades de pactar esta falta de velocidad dependiendo del contrato estándar de que se trate o del propio acuerdo que alcancen las partes al respecto. Incluso existen muchos contratos donde no se pacta ninguna indemnización y, por tanto, las reclamaciones por falta de velocidad se resuelven en los Tribunales o en la Cámara de Arbitraje.

Cálculo de consumo extra de combustible para llegar a la velocidad pactada

En el contrato se pacta una velocidad de servicio mínima correspondiente a un calado y una potencia determinada. Por ejemplo, el contrato estándar NEWBUILDCON establece una velocidad mínima de servicio a un calado de diseño y a un porcentaje de la potencia de salida del motor (*Maximum Continuous Range*) incluyendo, asimismo, el consumo a esa potencia y velocidad. De este modo que, si existe una deficiencia en la velocidad, podemos aumentar la carga del motor para llegar a la velocidad pactada. Ello supone un aumento del consumo que nos servirá para el cálculo de la indemnización.

Cálculo del coste extra de mantenimiento del motor

Un régimen más elevado de potencia supone disminuir el tiempo de los intervalos entre las revisiones para el mantenimiento del motor. Ello conlleva una disminución de la frecuencia temporal tanto en el cambio de piezas como en la realización de trabajos de mantenimiento. Asimismo, esta frecuencia dependerá de la diferencia entre ambas potencias: la contratada y la necesaria para proporcionar la velocidad pactada. Este dato debería estimarse como un porcentaje en base al coste anual de mantenimiento del motor principal.

Cálculo del coste extra de consumo de aceite

El aumento de aceite que supone el incremento de potencia puede obtenerse de la propia experiencia del motor en servicio. Para ello se comparan los consumos al régimen de potencia pactado y a la potencia necesaria para proporcionar la velocidad pactada. Si no existieran datos sobre la experiencia previa, el aumento de consumo de aceite puede considerarse proporcional al aumento del número de vueltas del motor.

Pérdida de flete

Si el buque consume más combustible para llegar a la velocidad pactada, la cantidad de combustible necesaria para mantener la misma autonomía del viaje se incrementa con la consiguiente reducción en el porte del buque al inicio del viaje. Esta pérdida será proporcional al tiempo y/o distancia del viaje marítimo y conllevaría una pérdida de flete que, a veces, puede ser absorbida por diferencias en el API si se trata de petroleros.

CONCLUSIÓN

Este método de cálculo puede ser útil para calcular el importe de la cláusula *liquidated damages* de los contratos de construcción de buques, que determina los perjuicios económicos causados por la falta de velocidad del buque.

Las variables del cálculo son reducidas básicamente al precio del combustible.

La desventaja del cálculo son el desconocimiento de las posibles fluctuaciones que sufrirá el precio de los combustibles derivados del petróleo durante los veinte años venideros.

Los datos empleados en este método se obtienen de las pruebas en banco del motor principal y su previo conocimiento hace el cálculo mas sencillo.

El coste extra en el mantenimiento del motor principal podría estudiarse en profundidad a fin de obtener una curva de regresión basada en los resultados y datos estadísticos de motores similares trabajando a diferentes regímenes de potencia.